The Run II Upgrade Program

Director's Review

May 2003

Program of upgrade projects in MI-Accumulator-Tevatron and the beam transfers

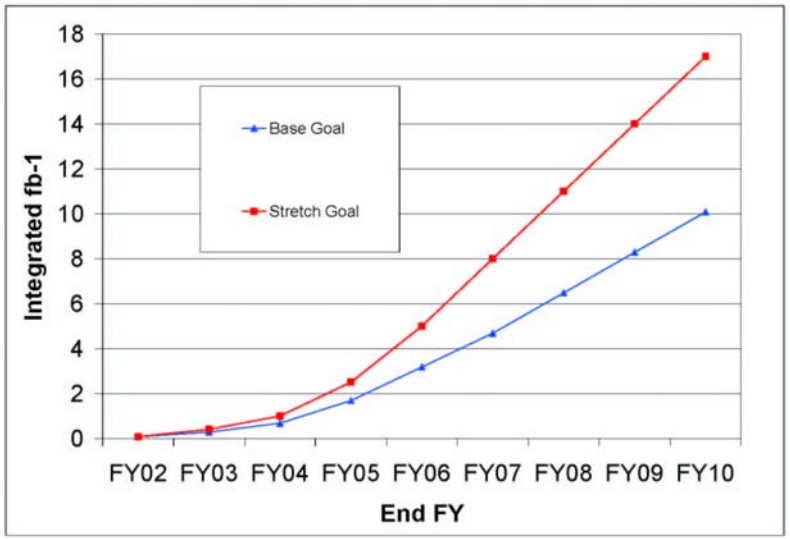
- Increase pbar stack size and production rate
- Upgrade Tevatron for higher bunch intensities

Performance Goals

- The goal of the Run II Upgrade Program is to maximize the integrated luminosity delivered to the CDF and D0, before experiments at the LHC begin reporting competitive physics results (expected 2009-2010).

- Target: Base and stretch goals DOE Review Oct 02

End FY08:
Stretch Goal 11 fb^{-1}
Base Goal 6.5 fb^{-1}

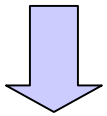


- Action Item: Develop Project Plan including Resource Loaded Schedule by June 1, Review in July

Goals

- Plan based on "Plan for Run IIb" with added emphasis on Tevatron improvements
- Base projections on system modeling: pbar production (stacking & cooling & transfers) and Tevatron stores

- Plan is constrained:
  - Develop a phased approach for upgrades, while continuing to operate and increase luminosity
  - Limited shutdowns: <6 wks per summer, ~7 mth for experiment upgrades in 2006

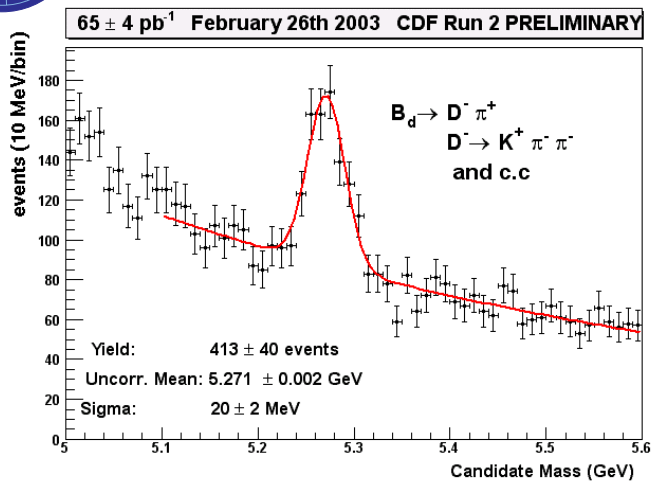


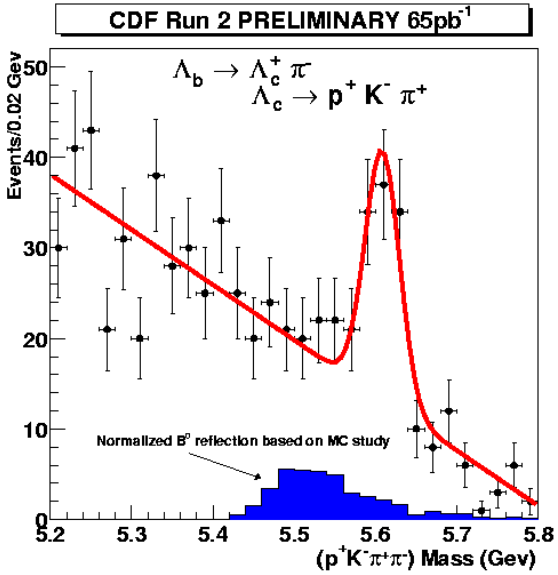
- Physics Program is ongoing and develops continuously as integrated luminosity increases

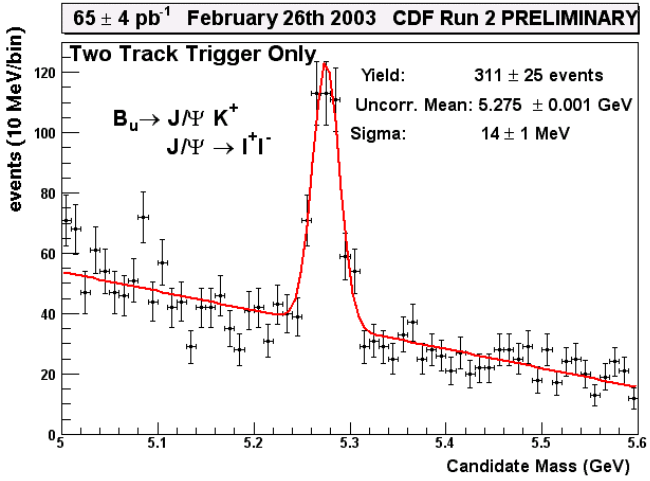
The Run II Physics Program

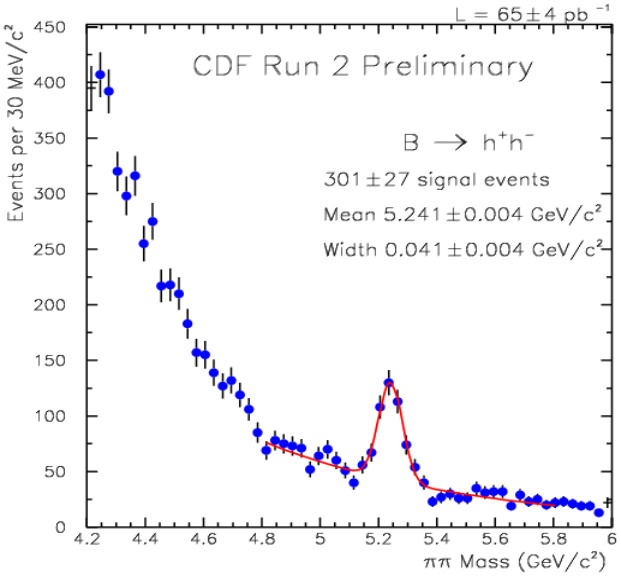
- Broad: from precision measurements that challenge the Standard Model to direct searches for new particles and forces
- Huge extension from Run 1
  - higher energy plus upgraded detectors → 1.5-4x
  - 1.2 fb-1 is 10x Run 1 luminosity, 12fb-1 is 100x
  - Top discovered in Run 1 with 10's of b-tagged events, Run II will deliver ~1000 per experiment in 2 fb^{-1}
- Physics program develops with luminosity, examples:
  - >100's pb^{-1}: high statistics studies in charm, beauty and top quark physics → parameters in the quark mixing matrix
  - ~2 fb^{-1}: precision top and W test electroweak in Standard Model and constrain SM Higgs
  - >2fb^{-1}: searches for new physics, including supersymmetry and Higgs → either discovery or exclude large regions of parameter space and provide direction for theoretical advances
  - and setting limits on other exotics – W', Z', compositeness, extra dimensions…

CDF: Exclusive beauty decays from 65 pb^{-1}









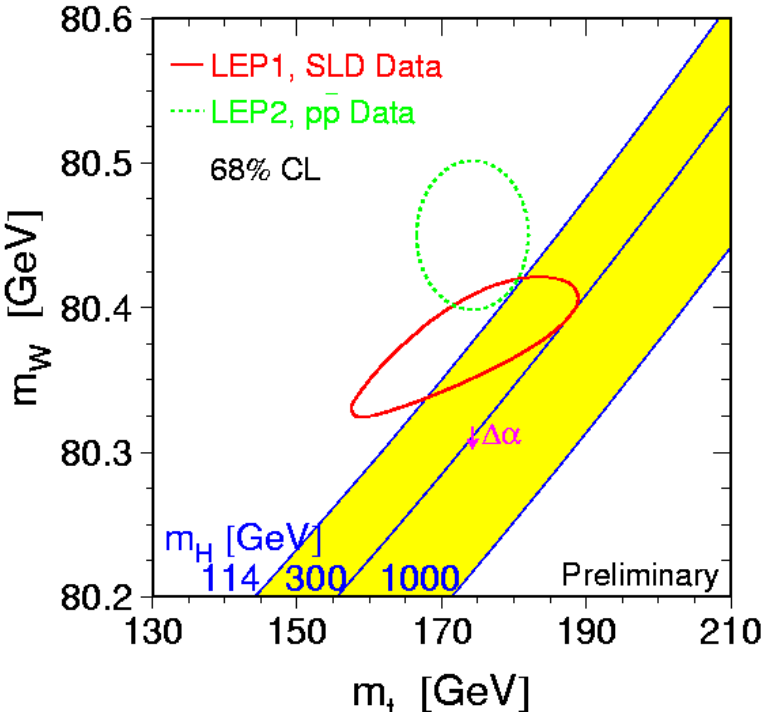
Prospects for electroweak measurements

Current knowledge of m_W

- DØ:
  - 80 483 ± 84 MeV
- hadron colliders:
  - 80 454 ± 59 MeV
- world:
  - 80 451 ± 33 MeV

Run II prospects (per experimen

	Δm_W
2 fb^{-1}	±27 MeV
15 fb^{-1}	±15 MeV

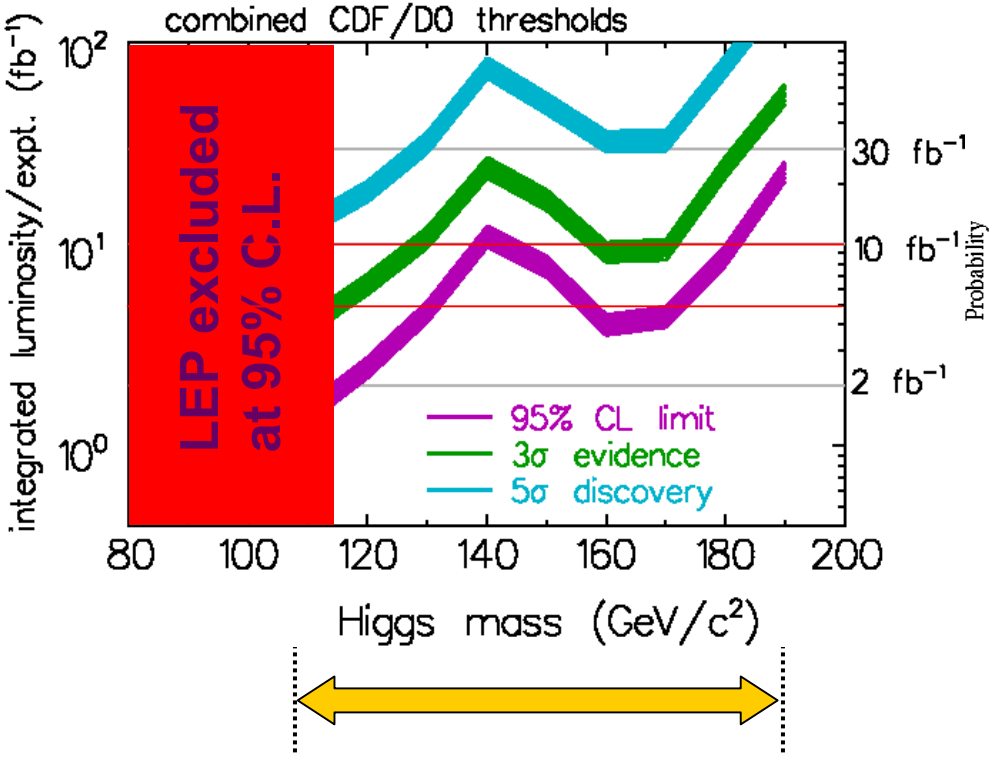


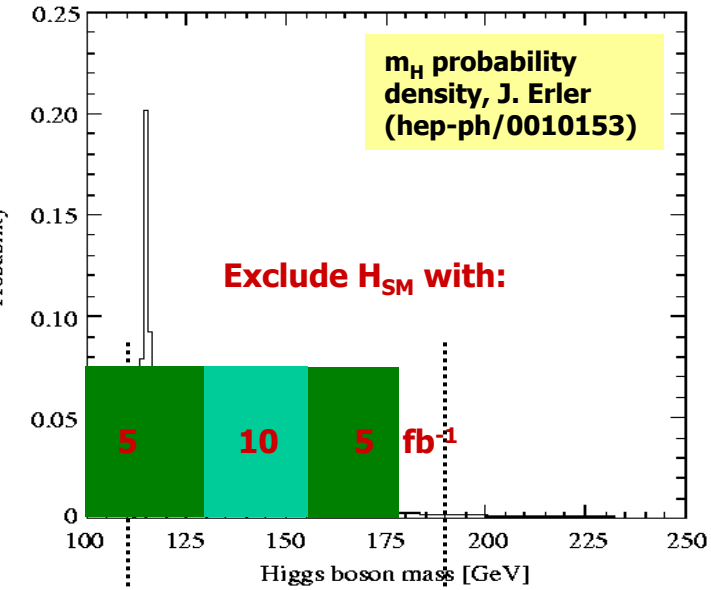
To improve on LEP will require >2 fb^{-1}

- We will also measure forward-backward asymmetry in Z production, multiboson production, boson + jets, ...

Tevatron Higgs mass reach

- developing analysis tools measuring backgrounds
- new estimates from CDF and D0 this summer





110-190 GeV

Performance Target

Compared to now

x1.3 ➡

x5 ➡

x3.5

x5.7 ➡

	Typical Run Ib	Store 2328	Goal: FY03	Run II Target	
Peak Luminosity	1.6	4.1	6.6	29.0	$x10^{31} cm^{-2} sec^{-1}$
Integrated Luminosity	3.1	6[(1)]	12.0	60.0	pb^{-1}/wk
Store hours per week	84	86[(3)]	81[(3)]	106	
Interactions/crossing	2.5	1.0	1.7	7.5	
Pbar Bunches	6	36	36	36	
Form Factor	0.59	0.60	0.63	0.63	
Protons/bunch	23.0	20.5	24.0	27.0	$x10^{10}$
Pbars/bunch	5.6	2.5	3.1	13.5	$x10^{10}$
Peak Pbar Prod. Rate	7.0	12[(2)]	18.0	45.0	$x10^{10}/hr$
Avg. Pbar Prod.Rate	4.2	7.0	11.0	40.0	$x10^{10}/hr$
Pbar Transmission Eff.	50	60	80	80%	%
Stack Used	67	152	141[(4)]	610	$x10^{10}$
MI extraction Long.Emit.		3.5	2.5	2.5	eV s
Bunch Length (rms)	0.6	0.6	0.54	0.54	m
Proton Emittance (at coll)	23	19	20	20	π-mm-mrad
Pbar Emittance (at coll)	13	14	15	14	π-mm-mrad
Store Length	16	22	15	15	hr

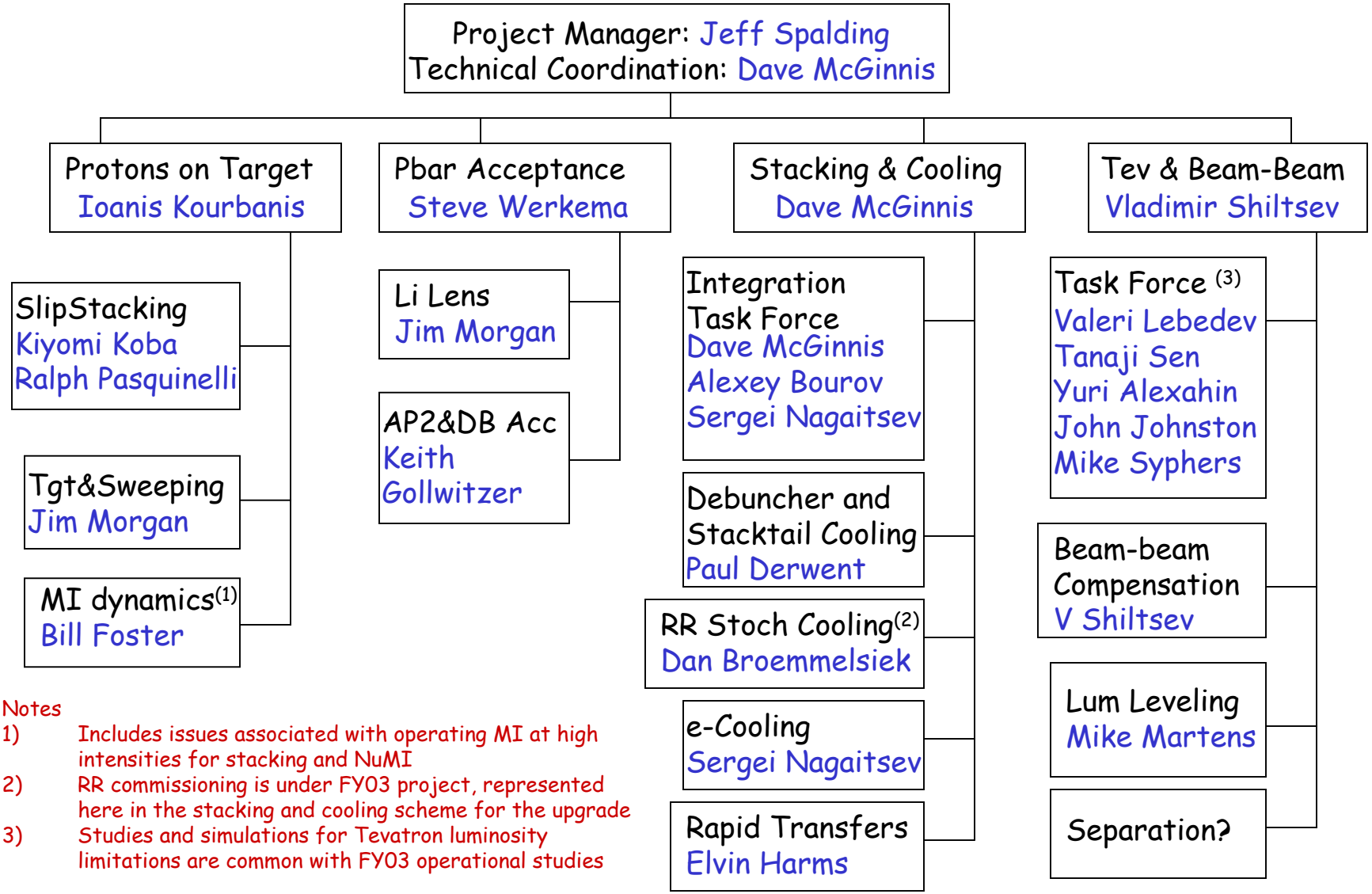
(1) typical April 03 (other numbers in this column are for store 2328)

(2) best stacking rate achieved $13.1x10^{10}/hr$ for one hour (peak ~14.5)

(3) excluding studies

(4) additional pBar stack used for RR commissioning

Project Organization



Notes

1) Includes issues associated with operating MI at high intensities for stacking and NuMI
2) RR commissioning is under FY03 project, represented here in the stacking and cooling scheme for the upgrade
3) Studies and simulations for Tevatron luminosity limitations are common with FY03 operational studies

Stacking and Cooling, and Tevatron Task Forces

→ Develop parametric models for pbar production and Tevatron stores

1. Develop specs and model for pbar production:
- accumulator with slip stacking (interim phase)
- accumulator transfers – RR(w/electron cooling)

→Develop project phasing and performance

→Dependence on key parameters

2. Develop model for Tevatron (initially w/o beam-beam effects, add understanding of beam-beam)

→Project phasing and scope for Tevatron upgrades

→Dependence of luminosity performance vs parameters

Project Planning

1. Define and review the subproject scope
   - Done for pbar subprojects, ongoing for Tevatron (milestones)
2. Develop plan for phasing the upgrades
   - Work in progress ← will show
3. Prepare WBS and Resource Loaded Schedule
   - Draft 1 ← will show summary
4. Develop Luminosity projection
   - From schedule+phases+modeling+ramp-up ← not yet

- Also! – continue to make technical progress

Biggest issue: personnel shared with near-term Ops

Project Scope

Evaluate in terms of benefit (contribution to luminosity), cost, effort and technical risk

- Drop:
  - 132 nsec operation
  - recycling pbars from Tevatron
- Essential components:
  - Slip stacking
  - AP2+DB Acceptance
  - Stacktail Cooling
  - Rapid Transfers
  - Electron cooling
- Under consideration:
  - Active beam-beam compensation
  - Increased beam separation

Project Scope

- 132 nsec operation
  - Original impetus for 132 nsec operation was to reduce the number of interactions /crossing for the experiments – this now appears manageable @396 (see below "luminosity leveling")
  - 132 requires a crossing-angle → ~40% red. in luminosity
  - Total protons x3 → concern about long range beam-beam interactions and instabilities
  - Would require large study and simulation effort
  - Significant work on hardware (separators, RF cavities… and instrumentation)

- pbar recycling
  - Historically ~30% of stores end prematurely
  - P. model: ~75% pbar left, 70% acceptance to RR

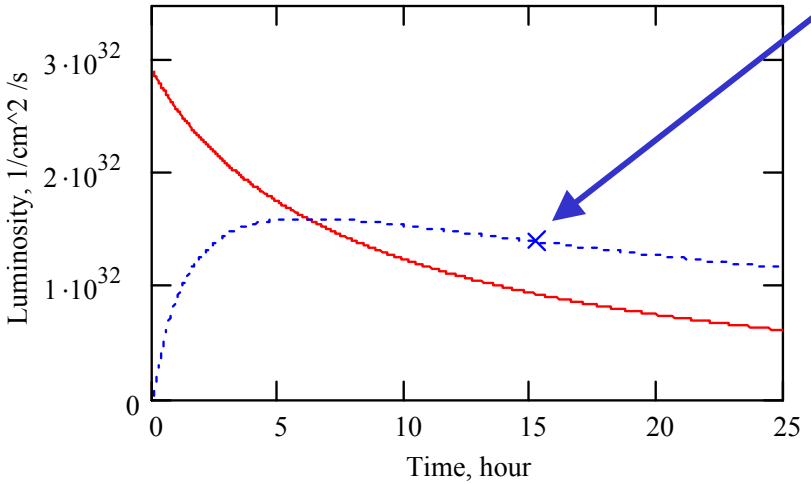
  } 37% pBars return to RR

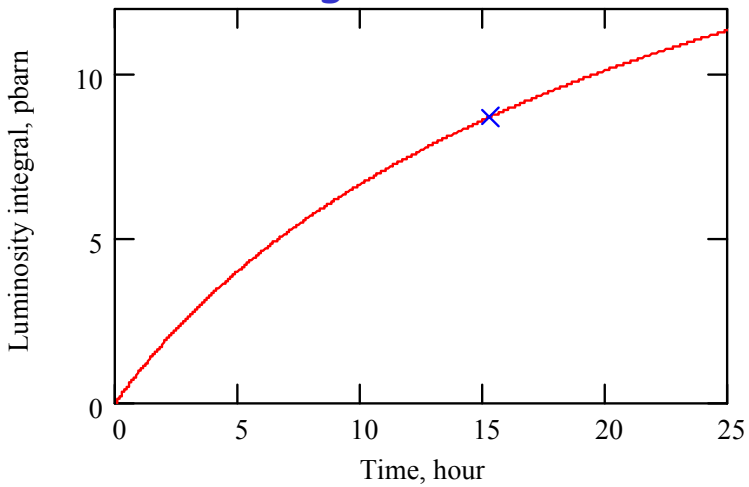
  - Recoup with longer stores → lose ~10% in integrated luminosity
  - Biggest issue is the timely removal of protons (without risk to experiments or quenching), followed by pbar deceleration

Tevatron Stores

- How robust is the integrated luminosity?
  - Luminosity Leveling @2E32 (worst case): lose ~12% (if required by experiments)
  - No recycling: lose ~10% (longer stores)
  - pbar=40%p: lose ~14% (shorter stores)
  - Average stacking = 30E10/hr: lose ~10% (longer stores)

average luminosity (incl shot setup) vs store length





Outstanding Scope Decisions

- Scope is generally well determined, and conceptual or engineering designs well advanced
- Scope cannot yet be defined for the AP2 & Debuncher Acceptance upgrade – first identify then correct aperture limitations ← use place holder estimates, and ongoing evaluation
- Plan for integrating RR & e-cooling not yet fully developed ← plan includes explicit evaluation
- Upgrade plans for the Tevatron to address beam-beam effects will be reviewed:
  - Plan to increase helix separation
  - Active beam-beam compensation: R&D → production

Today's Upgrade Talks

follow the Org chart

8:30:9:00	Introduction—Spalding
9:00-9:30	Intro-technical basis for the plan —McGinnis
9:30-10:15	Run II Operations Status—Church
10:30-11:30	Protons on Target—Kourbanis
11:30-12:30	Antiproton Acceptance—Werkema
13:30-14:30	Antiproton Stacking and Cooling—McGinnis
14:30-15:30	Tevatron Modeling and Upgrades—Lebedev
15:45-16:30	Project Planning —Spalding